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ABSTRACT

This paper reports on a 3-year computer initiative implemented by a school district in a metropolitan area. The initiative began in 1996 and continued through 1998. The school district of 44,000 students funded 5 computers and an ink jet color printer in each elementary classroom in 34 schools. The purpose of this study was to determine the impact of the initiative on student achievement and teacher behaviors. Data were collected through teacher surveys and standardized test scores. The first conclusion supported by the findings is that student achievement can be influenced by the appropriate integration of computer technologies into instruction. Students with access to computer aided instruction had increased standardized reading test scores. Different findings were noted for mathematics and writing. It is possible that the relationship between the initiatve and improved reading scores was influenced by intervening factors not measured in the study. Researchers also concluded that teachers' ability to integrate technology-assisted instruction into their classroom routines could be influenced by staff development and technology support. An implication from the analysis is that implementation planners should find ways to assist teachers in classroom management and positive external reinforcement schemes. (Contains 12 tables and 6 references.) (SLD)

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The Impact of Computers on

Student Performance and Teacher Behavior

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Abstract

This paper reports on a three-year Computer Initiative implemented by a school district in a metropolitan area. The Initiative began in 1996 and continued through 1998. The school district of 44,000 students funded five computers and an ink jet color printer in each elementary classroom in thirty-four schools.

The purpose of this study was to determine the impact of the Initiative on student achievement and teacher behaviors. Student performance was studied by looking at achievement, behavior, and performance. The Initiative's impact on teacher behavior focused on computer ability, beliefs and attitudes, instructional behavior, and work behavior.

Although data were collected through classroom observations, focus group interviews, teacher surveys, and standardized test scores, only teacher surveys and standardized test scores were reported in this study. Data were then organized and analyzed to examine the impact of computers on student performance and teacher behavior.

The first conclusion was that student achievement can be influenced by the appropriate integration of computer technologies into instruction. The study reported increases in reading standardized tests when comparing students who did not have access to computer aided instruction and those that did. Similar findings were not found in mathematics and writing. In light of a large sample size and the causal-comparative design, it is possible that the relationship between the Initiative and increased reading scores were influenced by intervening factors not measured in the survey, and the possible interaction between the types of software utilized by teachers, school district emphasis on curricular improvements, a concerted administrative support system that was put into place, and the ability of teachers to integrate technology into their instructional routines.

The researchers concluded that teacher ability to integrate technology-assisted instruction into their classroom routines could be influenced by staff development and technology support. Therefore, planners must consider providing teachers with continual technical and instructional support when implementing technology integration plans. By participating in the Initiative, over a relatively short time, previous computer and teaching experience was leveled and was no longer a determining factor in predicting ability to use the computer in the classroom. However, teachers were also influenced by external reinforcement from seeing improved student attention, motivation and performance they attribute to the technology aided instruction, administrative support in the form of principal observation, and interest in how they are using the technology and parental support they receive from feedback conferences. The implication from this analysis is that implementation plans should also find ways to assist teachers in classroom management and positive external reinforcement schemes.

Table of Contents

Purpose	5
Methodology	5
Findings	6
IMPACT OF THE COMPUTER INITIATIVE ON STUDENTS	6
Student Achievement	7
Student Behavior	10
Student Performance	11
IMPACT OF THE COMPUTER INITIATIVE ON TEACHERS	13
Computer Ability	13
Teacher Beliefs and Attitudes	14
Teacher Instructional Behavior	15
Teacher Work Behavior	18
Conclusions	20
Implications for Further Research	21
Selected References	22

List of Tables

Table 1: Mean Ability and Literacy Scores of "Before" and "After" Cohorts of All Sixth Graders

Table 2: Mean Ability and Literacy Scores of "Before" and "After" Cohorts of All Sixth Graders in Eight Selected Schools

Table 3: Analysis of Variance of LTP Reading Scores in Selected Schools by Group with Verbal Ability

Table 4: Teacher Perceptions of How Computers Changed Student Motivation to Learn from Year One to Year Three

Table 5: Teacher Perceptions of How Computers Changed Student Behavior from Year One to Year Three

Table 6: Teacher Perceptions of the Impact of the Computer Initiative on Student Performance from Year One to Year Three

Table 7: Teacher Perceptions of their Computer Ability Before and After the Computer Initiative by Grade Level

Table 8: Teacher Attitudes that Significantly Changed Over the Three-Year Period

Table 9: Significant Changes in Teachers' Perceptions of Instructional Goals for the Use of Computers in Their Classrooms from Year One to Year Three of the Computer Initiative

Table 10: Significant Changes in Teachers' Perceptions of Curricular Objectives for using Computers in Their Classrooms from Year One to Year Three of the Computer Initiative

Table 11: Instructional Behavior Survey Items on Which Teacher Responses Significantly Differed from Year One to Year Three

Table 12: Teacher Work Behavior Survey Items on Which Teacher Responses Significantly Differed from Year One to Year Three

The Impact of Computers on Student Performance and Teacher Behavior

Purpose

In 1996, a metropolitan school district of 44,000 students placed five computers and an ink jet color printer (the Computer Initiative) in each regular first through fifth grade classrooms in thirty-four elementary schools. The goals of the Initiative were numerous but focused on: (1) increasing student performance, (2) addressing different learning styles, (3) providing students with daily access to computers, (4) increasing student proficiency with computers, and (5) preparing students for the future. To accomplish these goals, teachers were required to acquire the capacity to integrate computers into their daily classroom lessons, and the school district needed to install and subsequently maintain the technical hardware and courseware required to support teacher efforts. The district also commissioned a longitudinal study to determine the impact of the Computer Initiative on student achievement, teacher behavior, administrative support, and parental support.

The purpose of this study was to determine the impact of the Initiative on student achievement and teacher behaviors. Student performance was studied by looking at achievement, behavior, and performance. The Initiative's impact on teacher behavior focused on computer ability, beliefs and attitudes, instructional behavior, and work behavior. The annual results were used formatively by the school district to make improvements in their implementation plans.

Methodology

One-hundred percent of the thirty-four elementary schools took part in the Initiative. It was recognized that the findings resulting from a causal-comparative research design would not be as conclusive as a tightly controlled experimental design. However, it was the school district's goal to initiate the use of computers in every classroom of every school instead of selecting experimental control schools and classrooms.

In the first year of the study, eight of these thirty-four schools were randomly selected for in-depth analyses over the three-year period. Data were collected on this sample each year of the study through teacher surveys and standardized test scores. Sixty-one percent of teachers from the schools returned the teacher surveys (n=87). Additionally, student standardized test scores were reported from all 34 schools. Designing the research project as a longitudinal study provided information on how technology was being assimilated and accommodated in the instructional environment. As Seidel and Perez (1994) noted, longitudinal studies enable the researcher to observe how teacher behavior, purposes, and attitudes might change over time.

It was hypothesized that the full impact of the Initiative on student achievement would not be achieved until at least the fifth year of the Initiative. Yet, student achievement on standardized test results was reviewed in the first and the third year of the study for comparative purposes. Student achievement was first studied by comparisons of before and after cohorts on standardized

tests in all thirty-four elementary schools and in a random sample of eight elementary schools. A limitation of the study was assessing student achievement only with standardized test results on a school-wide basis. Additionally, a large sample almost certainly yields statistically significant results. The findings would be considered to be practically significant if 10% of the variance between the pre-cohort and cohort test scores could be attributed to the Computer Initiative. This limitation was diminished to a small degree by examining teacher perceptions of student motivation to learn and performance that they could attribute to the Initiative.

The impact of the Initiative on student achievement was assessed by using the school's state testing program called the Literacy Testing Program. The Literacy Testing Program (LTP) has been administered by the school district to all students in grades six for a decade. Results of these LTP tests, in reading, math, and writing, were reported in standardized scores. These tests provided an opportunity to compare LTP results of the two cohorts of students prior to the Initiative with the LTP results of the first two cohorts of students that were involved in the Initiative. As a means of controlling any differences in potential ability of the cohorts involved, the test scores of the Cognitive Abilities Test (CogAT) were used as a covariant.

The impact of the Initiative on teacher behavior was also examined by comparing changes in teacher perceptions of their computer ability, attitudes, instructional, and work behaviors. Additionally, teachers were asked to judge students' motivation and performance over the three-year term. Teacher behavior was assessed each year by the use of a 113-item teacher survey. This instrument was created by using an expert panel and was pilot-tested with a group of thirty teachers in the first year of the study. The internal reliability was determined by using a Cronbach's Alpha, $\alpha = .89$ (n=65). Each year, the survey was reviewed by teacher focus groups, and improvements were made.

Each year, for three years, teachers from first through fifth grade in the randomly selected schools completed the 113-item teacher behavior survey. It is on these responses that this paper is based.

The survey data were first analyzed through descriptive statistics and displayed in tables for each question at aggregate and grade levels. Then, the responses of teachers in 1998 were compared by a repeated measures design to 1996 and 1997 survey results to determine if significant changes had occurred from year-one to year-three data. Paired t-tests were employed for these analyses; the criteria for selection was $p < .05$.

Findings

IMPACT OF THE COMPUTER INITIATIVE ON STUDENTS

The impact of the Computer Initiative on students was examined in three areas: (1) performance on standardized tests (achievement), (2) teacher perceptions of the Initiative's impact on student behavior and motivation to learn (behavior), and (3) teacher perceptions of the Initiative's impact on student performance (performance).

Student Achievement

The impact of the Initiative on student achievement after 3 years of implementation was measured by examining scores on the Literacy Testing Program (LTP) reading, math, and writing of students who were enrolled in the elementary schools prior to the placement of five computers in their classrooms.

The impact of the Initiative was investigated using the population of students from 34 elementary schools that received the computers. Sixth grade students who took the LTP the first two years between 1996-98 after the computers were introduced were combined as the group of students assessed "After" the Initiative began. A total of 4,328 "After" students had both LTP scores and CogAT scores for analyses.

Scores from sixth graders who took the LTP prior to the introduction of computers in the elementary schools were combined to form the group of students " Before" the Initiative began. A total of 4,123 "Before" students had both LTP scores and CogAT scores. Using an ANCOVA, the LTP test scores of the Before Cohort students were compared with the test scores of the After Cohort following three years of the Initiative. Using the Cognitive Aptitude Test scores as a covariant, differences in potential ability were controlled. The mean scores for these two groups are displayed on Table 1 showing students' ability and literacy scores.

Table 1
Mean Ability and Literacy Scores of "Before" and "After" Cohorts of All Sixth Graders

Grade 3 Ability and Grade 6 Literacy for All Schools								
Gr 3Yr	Mean Grade 3 Ability Scores				Gr 6Yr	Mean Grade 6 Literacy Scores			#
	Verbal	Quant	NonVerbal			Read	Math	Writing	
91-93	108.7	106.4	107.8		94-96	270.9	266.3	269.2	4122
93-95	108.2	108.9	108.8		96-98	273.0	267.7	268.6	4328

The results of this examination indicate that following three years of the Initiative:

- The Literacy Testing Program reading scores of the student cohorts involved in the Initiative were significantly higher than the student cohorts not involved in the Initiative. The mean reading literacy score of the "After" group (273.0) was higher than the "Before" group (270.9). This higher mean score of the "After" group was accentuated by the fact that the mean verbal ability of the "After" group (108.2) was slightly lower than the mean of the "Before" group (108.7).

- The mean writing and math literacy scores of student cohorts involved in the Initiative were not significantly different than student cohorts not involved in the Initiative. The literacy writing mean of the "After" group (268.6) was slightly lower than the "Before group mean (269.2). The math literacy mean of the "After" group (267.7) was slightly higher than the "Before" group mean (266.3). However, the mean quantitative ability of the "After" group (108.9) was slightly higher than the "Before" group (108.4 mean quantitative ability).

Eight schools were randomly drawn from the 34 elementary schools involved in the Computer Initiative for a more in-depth study on the effects of the Initiative. The ability and literacy test data for the students in the eight selected schools for in-depth study was isolated for further analysis. In Table 2, the mean ability and literacy scores for these schools are portrayed.

Table 2
Mean Ability and Literacy Scores of "Before" and "After" Cohorts of All Sixth Graders in Eight Selected Schools.

All Eight Selected Schools Grade 3 Ability and Grade 6 Literacy for All Schools								
Gr 3Yr	Mean Grade 3 Ability Scores				Gr 6Yr	Mean Grade 6 Literacy Scores			#
	Verbal	Quant	NonVerbal			Read	Math	Writing	
91-93	106.9	106.0	106.1		94-96	268.8	264.8	268.7	864
93-95	105.7	107.4	107.4		96-98	270.4	266.3	266.9	977

While mean scores, both ability and literacy, for students in the eight selected schools were lower than mean scores for the entire school district, the score patterns were similar to the patterns for all schools. Analysis of covariance was conducted between literacy means of the "Before" and "After" groups (Table 3). The corresponding ability test from the CogAT was included as a covariate to control for the differences in the ability of these two groups. The analysis of covariance was conducted with the Statistical Package for the Social Sciences (SPSS).

Table 3
Analysis of Covariance of LTP Reading Scores in Selected Schools by Group with Verbal Ability

Source of Variation	Sum of Squares	DF	Mean Square	F	p.
Covariates	338802.486	1	338802.486	2065.038	.000
Verbal Ability	338802.486	1	338802.486	2065.038	.000
Main Effects	2366.805	1	2385.805	14.420	.000
Group	2366.805	1	2385.805	14.420	.000
Explained	341168.292	2	170584.146	1039.729	.000
Residual	294006.241	1792	164.066		
Total	635174.533	1794	354.055		

1841 Cases were processed. 46 cases (2.5 PCT) were missing.

The results of this examination indicates that following 3 years of the Initiative:

- The Literacy Testing Program reading scores of the student cohorts involved in the Initiative were significantly higher than the student cohorts not involved in the Initiative. The mean verbal ability of the "After" group (105.7) was lower than the mean of the "Before" group (106.9). This difference was found to be significant at greater than the .001 level. The mean LTP Reading score of the "After" group (270.41) was significantly higher than the "Before" group (268.8) at greater than the .001 level. The significant differences between the two groups in the LTP reading score, with adjustments for differences in verbal ability, led to an explained variance that was significant at the .000 level.

- The mean writing and math literacy scores of student cohorts involved in the Initiative were not significantly different than student cohorts not involved in the Initiative. No significant differences were found between the literacy scores in writing and math when controlling for ability.

It can therefore be concluded that the student group which utilized computers had statistically significant LTP reading scores that was higher than the student scores from the previous group. However, one cannot make the conclusion that the computers caused the significant difference. While adjustments were made for differences in verbal ability of the two groups, there were no controls on many other factors that may have influenced the differences. In light of a large sample size and the causal-comparative design, it is possible that the relationship between the Initiative and increased reading scores were influenced by intervening factors not measured in the survey. Some of these factors may include the possible interaction between the types of software utilized by teachers, school district emphasis on curricular improvements, a concerted administrative support system that was put

into place, and the ability of teachers to integrate technology into their instructional routines.

In summary, the group of students that experienced the use of computers had a higher mean reading literacy score than the group of students that did not have the use of computers. These primary findings are supported by secondary information available to the school district. For example, the recent state testing program identified the school district's students as among the highest performing on writing portions of the examination. It could be concluded that improved achievement in writing resulted from a synergistic effect between the use of computers and teacher emphasis on the standards of learning which, incidentally, were the bases of the recent state testing program.

Student Behavior

Furthermore, on the teacher behavior surveys, teachers reported that the introduction of five computers into their classrooms has impacted student behavior. The computers have motivated students to write, and to a lesser degree, to read, learn, and perform math. Tables 4 shows teacher perception of how computers changed student motivation to learn from year one to year three.

Table 4

Teacher Perceptions of How Computers Changed Student Motivation to Learn from Year One to Year Three

Item Year 1	Item Year 2	Item Year 3	Question	% Year 1	% Year 2	% Year 3
82 ****	86	85	There is an increase in student motivation to write since the Initiative was introduced. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=26 A=45 D=28 SD=2	SA=53 A=41 D=4 SD=2	SA=49 A=47 D=4
83 ****	87	86	There is an increase in student motivation to learn since the Initiative was introduced. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=16 A=46 D=37 SD=1	SA=24 A=60 D=12 SD=3	SA=34 A=57 D=8 SD=1

Note: Not all item responses will equal 100% due to rounding and/or response error.
Paired t-tests were employed for these analyses. Items presented in the table demonstrated significant changes at $p < .05$.
* Statistically significant difference between year one and year two findings
** Statistically significant difference between year two and year three findings
*** Statistically significant difference between year one and year three findings
**** Statistically significant difference found each year

In year three of the Initiative, 26% of the teachers reported that they strongly agree and 45% agree that there has been an increase in their students' motivation to write. Only 4% of the teachers disagreed with this assessment.

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- Teachers responded to this increased motivation by expecting more from students in terms of correcting and editing their work. Eighty-six percent (86%) reported that they strongly agreed or agreed that they expect more in this regard from their students.

- Seventy-six percent (76%) of the teachers strongly agreed or agreed that there has been an increase in student motivation to read.

Student Performance

According to teacher responses, the Initiative provided other student benefits. For instance, the strongest effect of the Initiative on a student's behavior was seen in his/her ability to work cooperatively with other students since the Computer Initiative was introduced. Table 5 shows these results. For example, twenty-seven percent (27%) of the year three teachers strongly agreed that students' ability to work cooperatively with other students had been improved. This finding compares to twelve percent (12%) of year two teacher perceptions. However, it was also reported that student discipline had not decreased since the introduction of computers into their classrooms.

Table 5

Teacher Perceptions of How Computers Changed Student Behavior from Year One to Year Three

Item Year 1	Item Year2	Item Year3	Question	%Year 1	%Year 2	% Year3
93 ****	96	95	Discipline problems in my classroom have decreased since I began using computers in my teaching. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA 50% A=49% D=1%	SA=6% A=18% D=58% SD=17%	SA=5% A=23% D=61% SD=11%
94 ****	97	96	There is improved student/teacher rapport since the computer initiative was introduced. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=47% A=44% D=7% SD=2%	SA=12% A=33% D=47% SD=7%	SA=6% A=55% D=37% SD=1%
N/A **	99	98	Students have improved in their ability to work cooperatively with other students since the computer initiative was introduced. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	N/A	SA=12% A=61% D=22% SD=4%	SA=27% A=57% D=14% SD=1%
84 ****	88	87	Student attention improved since the initiative was introduced. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=26% A=63% D=10% SD=1%	SA=15% A=28% D=52% SD=5%	SA=11% A=46% D=41% SD=2%

Note: Not all item responses will equal 100% due to rounding and/or response errors.

Paired t-tests were employed for these analyses. Items presented in the table demonstrated significant changes at $p < .05$.

* Statistically significant difference between year one and year two findings
** Statistically significant difference between year two and year three findings
*** Statistically significant difference between year one and year three findings
**** Statistically significant difference found each year

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Additionally, teachers reported that improved student performance resulted for most students over the three year period. On the teacher behavior survey, teachers were asked, since they have been using computers, if high-achieving, average-achieving, and low-achieving students had profited. As seen on Table 6, they reported that students in every category had profited from the Initiative.

Table 6
Teacher Perceptions of the Impact of the Computer Initiative on Student Performance from Year One to Year Three

Item Year 1	Item Year 2	Item Year3	Question	%Year 1	%Year 2	% Year3
85 ****	90	89	My high achieving students have profited from the initiative. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=17% A=63% D=17% SD=2%	SA=65% A=35% D=0% SD=0%	SA=53% A=46% D=1%
86 ****	91	90	My average achieving students have profited from the initiative. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=25% A=52% D=21% SD=3%	SA=43% A=55% D=1% SD=0%	SA=46% A=54% D=0% SD=0%
87 ****	92	91	My low-achieving students have profited from the initiative. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=29% A=47% D=20% SD=4%	SA=45% A=47% D=7% SD=1%	SA=41% A=58% D=1% SD=0%
90 ****	93	92	Students have improved in completing class assignments. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=27% A=66% D=5% SD=2%	SA=16% A=36% D=46% SD=2%	SA=13% A=48% D=38% SD=1%
91 ****	95	94	Students have improved in their completion of their homework assignments since the computer initiative was introduced. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=55% A=42% D=3% SD=0%	SA=4% A=13% D=70% SD=13%	SA=4% A=14% D=61% SD=19%
54 ***	46	48	Since I have been using computers in the classroom, I can expect more from my students in terms of their pursuing and editing their work. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=47% A=45% D=5% SD=2%	SA=45% A=45% D=11% SD=0%	SA=32% A=59% D=8% SD=1%
96 ****	98	97	The grades of my students have improved because technology was introduced. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=20% A=54% D=24% SD=2%	SA=8% A=27% D=59% SD=4%	SA=6% A=41% D=52% SD=1%

Note: Not all item responses will equal 100% due to rounding and/or response errors.

Paired t-tests were employed for these analyses. Items presented in the table demonstrated significant changes at $p < .05$.
* Statistically significant difference between year one and year two findings
** Statistically significant difference between year two and year three findings
*** Statistically significant difference between year one and year three findings
**** Statistically significant difference found each year

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- Fifty-three percent (53%) of the teachers strongly agree that high-achieving students had profited.

- Forty-six percent (46%) of the teachers strongly agreed that the performance of their average achieving students improved since they have been using computers in their classrooms.

- Forty-one percent (41%) of the teachers strongly agreed that their low achieving students' performance improved.

- Ninety-one percent (91%) of the year three teachers perceive that their students' research skills have improved since they have used computers in their classrooms. This perception is similar to year two teachers (93%).

It should also be noted that overall, teachers reported little improvement in grades, class assignments, and completion of homework assignments since the introduction of computers in their classrooms.

THE IMPACT OF THE INITIATIVE ON TEACHERS

The impact of the Initiative on Teacher behavior is reported around the following four areas of concern: (1) computer ability, (2) teacher beliefs and attitudes, (3) teacher instructional behavior, and (4) teacher work behavior.

Computer Ability

Teacher capacity to implement the Initiative was studied through the concept of computer ability. The concept was used first to identify teacher knowledge and skill level relative to using computers in their classrooms. Teachers were first asked to identify their ability level prior to the Initiative. They were then asked to make the same assessment at the end of each year of the Initiative. The results of this assessment, displayed in Table 7, indicate that the Initiative had a dramatic impact on teacher ability to integrate computers into instruction. For example, non-technology using teachers were eliminated after the first year of the Initiative.

Table 7
Teacher Perceptions of their Computer Ability Before and After the Computer Initiative by Grade Level

	Total				Grade Level																			
					1				2				3				4				5			
Ability Level	Y0	Y1	Y2	Y3	Y0	Y1	Y2	Y3	Y0	Y1	Y2	Y3	Y0	Y1	Y2	Y3	Y0	Y1	Y2	Y3	Y0	Y1	Y2	Y3
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Non-User	87	6	0	0	88	6	0	0	80	13	0	0	76	5	0	0	95	0	0	0	100	10	0	0
Novice	11	23	0	1	13	16	0	5	13	13	0	0	19	19	0	0	6	32	0	0	0	50	0	0
Beginner	1	56	38	24	0	59	42	18	0	33	46	18	5	76	44	45	0	63	20	17	0	20	43	14
Advanced	0	11	44	48	0	9	42	55	0	40	23	18	0	0	44	45	0	5	65	50	0	10	36	64
Accomplshd	1	4	18	27	0	9	15	23	7	0	31	64	0	0	11	10	0	0	15	33	0	10	21	21
# Respondent	98	98	83	85	32	32	26	22	15	15	13	11	21	21	9	20	19	19	29	18	11	10	14	14

Note: Not all item responses will equal 100% due to rounding and/or response errors.

Legend : **Novices** – can perform only simple tasks on the computer with some difficulty. **Beginners** - can perform basic computer tasks (e.g. word processing) quite well, although they might not know or utilize the full potential of the program. **Advanced** - can perform numerous tasks on the computer (e.g. word-processing, graphics, information management etc.) quite well and is familiar with the software=s capabilities. **Accomplished** - know a great deal about computer software and hardware, and can perform many tasks using a variety of software.

Fifty-six percent (56%) of year one teachers reported that they were Beginners (i.e., they can perform basic computer tasks such as word processing quite well, although they do not know or utilize the full potential of the program). This percentage declined to twenty-four percent (24%) by year three.

Eleven percent (11%) of year one teachers reported that they were Advanced computer users (i.e., they can perform numerous tasks on the computer such as word-processing, graphics, and information management quite well and are familiar with the software's capabilities). This percentage increased to forty-eight percent (48%) in year three.

One percent (1%) of year one teachers reported that they were Accomplished computer users (they know a great deal about computer software and hardware and can perform many tasks using a variety of software). This total increased to twenty-seven percent (27%) of the respondents in the third year of the Initiative.

Teacher Beliefs and Attitudes

The concept of teacher attitudes regarding their ability to integrate computers into their instruction and the utility of computers in instruction was also examined in each of the three years. Factors related to changes were also identified. Teacher reaction to computers in their classrooms was overwhelmingly supportive. They continued to see the computers as very important to their work as a classroom teacher. For example, more teachers in years two and three significantly reported that their

interest and knowledge about technology had increased than teachers in year one of the implementation of the Initiative.

Second, significantly fewer teachers in years two and three perceived that their knowledge was a barrier to using the computers effectively in their classrooms than teachers in year one. In particular, significantly more teachers in year three perceived that it is their technical knowledge that was a barrier to effectively using computers in their classrooms.
than in year one
Furthermore, significantly more teachers in years two and three reported that they enjoyed working with their students on the computer. Table 8 displays significant changes in teacher attitudes over the three-year period.

Table 8
Teacher Attitudes that Significantly Changed Over the Three-Year Period

Item Year 1	Item Year 2	Item Year 3	Question	% Year 1	% Year 2	% Year 3
68 ****	67	69	The computer initiative has increased by interest in and knowledge about technology. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=22 A=58 D=12 SD=7	SA=65 A=35 D=2 SD=0	SA=66 A=31 D=3 SD=0
100 ****	103	102	A CURRENT barrier to most effectively using the Initiative's classroom computers is that my knowledge of computers is still too weak to use them effectively. MD=Most Difficult; MMD=More than Moderately Difficult; MoD=Moderately Difficult; LMD=Less than Moderately Difficult; LD=Least Difficult	MD=8 MMD=47 MoD=39 LMD=5 LD=0	MD=2 MMD=6 MoD=13 LMD=22 LD=57	MD=1 MMD=4 MoD=18 LMD=29 LD=48
104 ****	107	106	A CURRENT barrier to most effectively using the Initiative's classroom computers is that I don't understand the technical side of the initiative. MD=Most Difficult; MMD=More than Moderately Difficult; MoD=Moderately Difficult; LMD=Less than Moderately Difficult; LD=Least Difficult	MD=4 MMD=40 MoD=51 LMD=4 LD=0	MD=10 MMD=17 MoD=25 LMD=28 LD=21	MD=26 MMD=14 MoD=11 LMD=20 LD=29
67 ****	66	68	I enjoy working with my students on the computer. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=28 A=59 D=13 SD=0	SA=57 A=39 D=2 SD=2	SA=57 A=41 D=2 SD=0

Note: Not all item responses will equal 100% due to rounding and/or response errors
Paired t-tests were employed for these analyses. Items presented in the table demonstrated significant changes at $p<.05$.
*Statistically significant difference between year one and year two findings
**Statistically significant difference between year two and year three findings
***Statistically significant difference between year one and year three findings
****Statistically significant difference found each year

Teacher Instructional Behavior.

The concept of instructional behaviors was used to identify the educational purpose of teachers' use of computers, planning behaviors to integrate computers into their

instruction, classroom organizational behaviors, and software usage.

Teachers reported that they used the computers in their classrooms to: (1) introduce new concepts by preparing students for instruction on a topic by using an appropriate software package, (2) reinforce the core curriculum by providing students with extra practice on material already learned, (3) extend the core curriculum by providing additional information on a topic, and/or (4) remediate the core curriculum by providing appropriate software for students who need additional help on a topic. Table 9 shows significant changes in teacher perceptions over the three-year period.

Table 9
Significant Changes in Teachers' Perceptions of Instructional Goals for the Use of Computers in Their Classrooms from Year One to Year Three of the Computer Initiative

Item Year 1	Item Year 2	Item Year 3	Question	% Year 1	% Year 2	% Year 3
34 ****	28	30	I use the computers in the classroom to reinforce the core curriculum. MIG=Most Important Goal; PG=Primary Goal; MG=Moderate Goal; LIG=Least Important Goal	MIG=3 PG=31 MG=43 LIG=23	MIG=37 PG=39 MG=24 LIG=0	MIG=41 PG=46 MG=13 LIG=0
35 ****	29	31	My goal for using the computers in the classroom is to extend the core curriculum. MIG=Most Important Goal; PG=Primary Goal; MG=Moderate Goal; LIG=Least Important Goal	MIG=56 PG=39 MG=9 LIG=0	MIG=45 PG=45 MG=9 LIG=1	MIG=8 PG=11 MG=42 LIG=38
36 ****	30	32	I use the computer in the classroom to remediate core curriculum. MIG=Most Important Goal; PG=Primary Goal; MG=Moderate Goal; LIG=Least Important Goal	MIG=41 PG=52 MG=7 LIG=0	MIG=12 PG=27 MG=29 LIG=33	MIG=9 PG=28 MG=37 LIG=26

Note: Not all item responses will equal 100% due to rounding and/or response errors.
Paired t-tests were employed for these analyses. Items presented in the table demonstrated significant changes at p<.05.
*Statistically significant difference between year one and year two findings
**Statistically significant difference between year two and year three findings
***Statistically significant difference between year one and year three findings
****Statistically significant difference found each year

Second, teachers reported that their primary curricular objective was improvement of language arts rather than math, social studies, or science. For example, fifty-eight percent (58%) of the teachers responded that improving language arts skills was the primary goal for using computers in the classroom. In this area, seventy-four percent (74%) indicated that their primary objective was to use computers to improve writing skills, and fifty-two (52%) reported using classroom computers to

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improve reading skills. On the other hand, teachers ranked mathematics, social studies, and science as moderate instructional objectives for computer use by teachers. Table 10 displays significant changes in teachers' perceptions of curricular objectives.

Table 10
Significant Changes in Teachers' Perceptions of Curricular Objectives for using Computers in Their Classrooms from Year One to Year Three of the Computer Initiative

Item Year 1	Item Year 2	Item Year 3	Question	% Year 1	% Year 2	% Year 3
39 ****	34	36	Improving language arts skills is an objective for using the computer in the classroom. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=28 A=46 D=21 SD=5	SA=55 A=41 D=2 SD=1	SA=58 A=38 D=5 SD=0
41 ****	36	38	Improving writing skills is an objective for using the computer in the classroom. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=39 A=43 D=16 SD=2	SA=68 A=32 D=0 SD=0	SA=74 A=24 D=2 SD=0
37 ****	32	34	Mastering math skills is an objective for using the conputer in the classroom. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=10 A=24 D=66 SD=0	SA=27 A=57 D=11 SD=6	SA=26 A=54 D=18 SD=2
38 ***	33	35	Learning to apply math is an objective for using the computer in the classroom. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=28 A=45 D=22 SD=5	SA=30 A=57 D=11 SD=2	SA=37 A=57 D=7 SD=0
43 ****	38	40	Understanding science is an objective for using the conputer in the classroom. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=8 A=36 D=42 SD=14	SA=13 A=55 D=27 SD=4 DK=1	SA=17 A=54 D=27 SD=1
42 ****	37	39	Understanding social studies is an objective for using the computer in the classroom. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=85 A=11 D=2 SD=2	SA=15 A=48 D=31 SD=7	SA=14 A=58 D=25 SD=2

Note: Not all item responses will equal 100% due to rounding and/or response errors
Paired t-tests were employed for these analyses. Items presented in the table demonstrated significant changes at $p<.05$.
*Statistically significant difference between year one and year two findings
**Statistically significant difference between year two and year three findings
***Statistically significant difference between year one and year three findings
****Statistically significant difference found each year

Third, teachers reported that some of their instructional strategies significantly changed from year one to year three. The five significantly different responses from year one to year three of the Initiative are described in Table 11.

Table 11

Classroom Behavior Survey Items to Which Teacher Responses Significantly Differed in Years 1 to 2 and 2 to 3

Yr 1 Item	Yr 2 Item	Yr 3 Item	Question	Year 1 %	Year 2 %	Year 3 %
57 **	52	54	I spend less time lecturing to the entire class (whole group instruction) SA=Strongly Agree, A=Agree, D=Disagree, SD=Strongly Disagree	SA=22% A =51% D =26% SD= 1%	SA=23% A =52% D =25% SD= 0%	SA=22% A =42% D =29% SD= 5%
58 ** ***	53	55	I spend less time with the whole class practicing or reviewing material SA=Strongly Agree, A=Agree, D=Disagree, SD=Strongly Disagree	SA=19% A =51% D =29% SD= 1%	SA=19% A =51% D =29% SD= 1%	SA=14% A =45% D =36% SD= 5%
60 *** *	55	57	I use a thematic approach across subject areas. SA=Strongly Agree, A=Agree, D=Disagree, SD=Strongly Disagree	SA=16% A =34% D =42% SD= 8%	SA=41% A =30% D =28% SD= 1%	SA=27% A =53% D =20% SD= 0%
77 *** *	79	81	The computer Initiative has changed my approach to classroom management and instruction. SA=Strongly Agree, A=Agree, D=Disagree, SD=Strongly Disagree	SA=55% A =41% D = 3% SD= 1%	SA=33% A =49% D =16% SD= 2%	SA=21% A =52% D =26% SD= 0%
60	54	N/A	Since I have been using computers I am better able to present more complex material to my students SA=Strongly Agree, A=Agree, D=Disagree, SD=Strongly Disagree	SA=16% A =34% D =42% SD= 8%	SA=28% A =42% D =29% SD= 1%	N/A

Paired t-tests were employed for these analyses. Items presented demonstrated significant changes at $p < .05$

- Significantly fewer teachers strongly agreed in year three than did in year two that trying out new techniques in instruction was needed for optimizing student education.

- Significantly more teachers in year three responded that they spend less time lecturing to the entire class than teachers did in year two.

- Significantly more teachers in year three spend time practicing or reviewing material with the whole class than teachers did in year two.

Teacher Work Behavior

The concept of work behaviors was used to identify changes in how teachers related to one another, planned, and assessed their work. Teachers believed they (1) were better able to present more complex material to their students, (2) use less lecture and whole class instruction, and (3) use more small group instructional strategies. Table 12 shows the survey responses which significantly differed over the three-year study.

First, there was a strong consensus among teachers that the computers allowed them to create better products such as newsletters. For example, ninety-eight percent (98%) of the teachers strongly agreed or agreed with the statement.

Table 12

Teacher Work Behavior Survey Items on Which Teacher Responses Significantly Differed from Year One to Year Three

Item Year 1	Item Year 2	Item Year 3	Question	% Year 1	% Year 2	% Year 3
N/A **	81	83	I use the school district Resource Guide for lesson plan ideas. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	N/A	SA=15 S=54 D=20 SD=11	SA=28 S=58 D=13 SD=1
72 *** *	73	75	I discuss technology, ideas, and resources with other teachers. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=28 S=59 D=13 SD=0	SA=39 S=58 D=4 SD=0	SA=35 S=61 D=4 SD=0
75 *** *	77	79	The Computer Initiative has encouraged me to plan cooperatively with other staff. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=37 S=45 D=16 SD=2	SA=27 S=40 D=34 SD=0	SA=17 S=51 D=31 SD=1
97 *	100	99	A CURRENT barrier to most effectively using the Initiative's classroom computers is that there is not enough time to develop lessons that use computers. MD=Most Difficult; MMD=More than Moderately Difficult; MoD=Moderately Difficult; LMD=Less than Moderately Difficult; LD=Least Difficult	MD=40 MMD=28 MoD=24 LMD=5 LD=3	MD=55 MMD=30 MoD=7 LMD=5 LD=2	MD=54 MMD=25 MoD=19 LMD=0 LD= 2
98 *** *	101	100	A CURRENT barrier to most effectively using the Initiative's classroom computers is that there is not enough help for supervising student computer use. MD=Most Difficult; MMD=More than Moderately Difficult; MoD=Moderately Difficult; LMD=Less than Moderately Difficult; LD=Least Difficult	MD=19 MMD=57 MoD=22 LMD=2 LD=0	MD=17 MMD=27 MoD=33 LMD=17 LD=7	MD=19 MMD=39 MoD=24 LMD=8 LD=10
73 *** *	74	76	The computers have been helpful to me in managing grades. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=51 S=40 D=8 SD=1	SA=20 S=11 D=49 SD=21	SA=18 S=13 D=45 SD=17
74 ****	75	77	The computers have been helpful to me in managing student information. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	SA=35 S=39 D=22 SD=2	SA=19 S=43 D=25 SD=11	SA=19 S=31 D=32 SD=8
N/A **	76	78	The computers have allowed me to produce better products such as newsletters. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree	N/A	SA=72 S=24 D=1 SD=2	SA=61 S=37 D=2 SD=0

Note: Not all item responses will equal 100% due to rounding and/or response errors

Paired t-tests were employed for these analyses. Items presented in the table demonstrated significant changes at $p<.05$.

*Statistically significant difference between year one and year two findings
**Statistically significant difference between year two and year three findings
***Statistically significant difference between year one and year three findings
****Statistically significant difference found each year

Second, teachers at all grade levels indicated that they discussed technology ideas with other teachers. However, teachers in the primary grades engaged in more cooperative planning with their colleagues than the teachers at the upper grades.

Conclusions

IMPACT OF COMPUTERS ON STUDENTS

A major conclusion of the study was that teachers attributed to the Computer Initiative improvements in (1) student achievement, (2) student work behavior, and (3) student performance. The first conclusion was that student achievement can be influenced by the appropriate integration of computer technologies into instruction. The study reported increases in reading standardized tests when comparing students who did not have access to computer aided instruction and those that did. Similar findings were not found in mathematics and writing. The researchers concluded that the increases in reading were influenced by the ability of teachers to integrate technology into their instructional routines, the types of software utilized by teachers, school district emphasis on curricular improvements, and a concerted administrative support system that was put into place. Therefore, there was probably not a direct correlation between providing computer aided instruction. The relationship was more synergistic. Therefore, when implementing technology interventions, planners must consider providing continual technical and instructional support to teachers.

IMPACT OF COMPUTERS ON TEACHERS

Similarly, the second conclusion of this study was that teacher ability to integrate technology assisted instruction into their classroom routines can also be influenced by the same array of factors, i.e., staff development and technical support. Teachers perceived that their ability to integrate technology into their instruction and their teaching behaviors were positively impacted by the Initiative. By participating in the Initiative, over a relatively short time, previous computer and teaching experience was leveled and nc longer a determining factor in predicting ability to use the computer in the classroom. This finding lends support to a second year conclusion that computer ability can be influenced by factors such as training, instruction, and administrative support particularly when they are implemented in unison.

Interestingly, teachers are also influenced by external reinforcement from seeing improved student attention, motivation, and performance they attribute to the

technology aided instruction, administrative support in the form of principal observation and interest in how they are using the technology and parental support they receive from feedback conferences. The implication from this analysis is that implementation plans should also find ways to assist teachers in classroom management and positive external reinforcement schemes.

Implications for Further Research

From this study, it is apparent that teachers believed that the computer's role is necessary, and rather crucial, for transforming and improving instruction. A great deal of data were collected over the three year time period, which lend to a variety of analyses. There arise several possibilities and implications for further research in this area of technology. Possible studies could include a close examination of school cultural factors and climate, in relation to a school division's readiness for large scale technology initiative. Additionally, further research might include an examination of the differences and similarities between the schools with the most proficient students and the schools with the least proficient students. In this case the researcher would be looking for significant differences in student and teacher behaviors, motivation, and performance.

Moreover, how an administrator supports and impacts teacher performance and student behavior could provide the basis for a future study. Additional research may also include studying the age/generation factor of the teacher as it relates to computers and attitude, motivation, and performance.

Finally, rather than basing students' behaviors and performance on teachers' perceptions, perhaps using a standardized technology component to assess ability may be more appropriate. By using student performance-based assessments on a random sample across the school division, a researcher may be better able to draw accurate conclusions.

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